

**WE CLAIM:**

1. A method of JPEG compression of an image frame divided  
up into a plurality of non-overlapping, tiled 8 x 8 pixel blocks  
5  $B_{ij}$ , where  $i, j$  are integers covering all of the blocks in the  
image frame, comprising:

(a) forming a discrete cosine transform (DCT) of each  
block  $B_{ij}$  of the image frame to produce a matrix of blocks of  
10 transform coefficients  $D_{ij}$ ;

(b) calculating a visual importance,  $I_{ij}$ , for each  
block of the image, based upon assigning zeros for flat features  
and values approaching unity for sharply varying features;

(c) forming a global quantization matrix  $Q$  by one of

(i) selecting a standard JPEG quantization table  
and

20 (ii) selecting a quantization table such that the  
magnitude of each quantization matrix coefficient  
 $Q_{ij}$  is inversely proportional to the importance in  
the image of the corresponding DCT basis vector;  
and

25 (d) selecting a linear scaling factor  $S_{ij}$  defining  
bounds over which the image is to be variably quantized;

(e) quantizing the transform coefficients,  $D_{ijmn}$ , by an equivalent of dividing them by a factor  $S_{min} * Q$ , where  $S_{min}$  is a user selected minimum scaling factor, and

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(f) entropy encoding quantized coefficients  $T_{ijmn}$  and  $Q * S_{min}$  to create a JPEG image file.

2. A method according to claim 1, wherein step (e) includes rounding  $(D_{ijmn} / (S_{min} * Q))$  to the nearest integer to form quantized DCT transformed coefficients  $T_{ijmn}$ ;

(a) setting  $T_{ijmn} = 0$  if  $\text{round}(D_{ijmn} / (Q_{mn} * S_{ij})) = 0$ ; and

(b) setting  $T_{ijmn} = \text{sign}(D_{ijmn}) * (2^{(\text{ceil}(\lg(\text{abs}(D_{ijmn}) + 1)) - 1) - 1)$  if  $\text{abs}(D_{ijmn}) - (2^{(\text{ceil}(\lg(\text{abs}(D_{ijmn}) + 1)) - 1) - 1)$  is less than or equal to  $\text{abs}(D_{ijmn} - Q_{mn} S_{ij} * \text{round}(D_{ijmn} / (S_{ij} * Q_{mn})))$ ;

3. A method according to claim 1, including calculating a linear scaling factor  $S_{ij}$  equal to  $I_{ij} * (S_{max} - S_{min}) + S_{min}$  where  $S_{min}$  and  $S_{max}$  are user specified to define bounds over which the image will be variably quantized.

4. The method according to claim 1, where  $I_{ij}$  is determined by discrete edge detection and summation of transform coefficients.

5. The method according to claim 1, wherein  $I_{ij}$  is determined by creating a 24 x 24 matrix of image pixels of DCT coefficients centered on a block  $B_{ij}$ , where  $i$  and  $j = 1, 2, \dots, 8$ , convolving said 24 x 24 matrix with an edge tracing kernel to produce a convolved matrix, summing center 10 x 10 matrix values of said convolved matrix to produce a summed value, and normalizing said summed value to produce a visual importance,  $I_{ij}$ .

6. The method according to claim 1, wherein said  $Q$  is formed by calculating an 8 x 8 matrix  $A$  by calculating matrix elements  $A_{mn}$  of said  $A$  according to the formula

$$A_{mn} = \sum_{(i,j)} I_{ij} (B_{ij})_{mn},$$

calculating elements  $Q_{mn}$  of said  $Q$  according to the formula

$$Q_{mn} = \max(A_{mn}) / A_{mn}$$

and scaling values of  $Q_{mn}$  for all values of  $(m,n)$  except  $(0,0)$  in order to minimize an error between  $Q$  and a standard JPEG quantization matrix.

7. A method of JPEG compression of an image frame divided up into a plurality of non-overlapping, tiled 8 x 8 pixel blocks  $B_{ij}$  where  $i, j$  are integers covering all of the blocks in the image frame, comprising:

(a) forming a discrete cosine transform (DCT) of each block  $B_{ij}$  of the image frame to produce a matrix of blocks of transform coefficients  $D_{ij}$ ;

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(b) calculating a visual importance,  $I_{ij}$ , for each block of the image, based upon assigning zeros for flat features and values approaching unity for sharply varying features;

(c) forming a global quantization matrix  $Q$  by one of

(i) selecting a standard JPEG quantization table and

(ii) selecting a quantization table such that the magnitude of each quantization matrix coefficient  $Q_{ij}$  is inversely proportional to a visual importance,  $I_{ij}$ , to the image of a corresponding DCT basis vector; and

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(d) selecting a linear scaling factor  $S_{ij}$  defining bounds over which the image is to be variably quantized wherein  $S_{ij} = l_{ij}(S_{\max} - S_{\min}) + S_{\min}$ , where  $S_{\max}$  and  $S_{\min}$  are user selected;

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(e) quantizing the transform coefficients,  $D_{ijmn}$ , to produce quantized blocks  $T_{ijmn}$  as follows:

(i)  $T_{ijmn} = \text{round}(D_{ijmn} / (S_{\min} * Q_{mn}))$ , where round denotes rounding to the nearest integer;

(ii) setting  $T_{ijmn} = 0$  if  $\text{round}(D_{ijmn} / (Q_{mn} * S_{ij})) = 0$ ;

5 and

(iii) setting  $T_{ijmn} =$

$\text{sign}(D_{ijmn}) * (2^{(\text{ceil}(\lg(\text{abs}(D_{ijmn}) + 1)) - 1) - 1}$  if  $\text{abs}(D_{ijmn}) -$   
 $(2^{(\text{ceil}(\lg(\text{abs}(D_{ijmn}) + 1)) - 1) - 1}$  is less than or equal to  $(\text{abs}(D_{ijmn}) -$   
10  $Q_{mn} * S_{ij} * \text{round}(D_{ijmn} / (S_{ij} * Q_{mn})))$ ;

(f) entropy encoding quantized coefficients  $T_{ijmn}$  and  $Q * S_{\min}$ , to create a JPEG image file.

15 8. A method of JPEG compression of a colour image represented by channels Y for greyscale data, and U and V each for colour, comprising:

20 (a) shrinking the colour channels U and V by a fraction of their size;

(a) forming a discrete cosine transform (DCT)  $D_{ij}$  for each block  $B_{ij}$  of each of channels Y, U and V;

25 (b) calculating a visual importance,  $I_{ij}$ , for each Y channel block of each image and setting  $I_{ij} = \max\{ I_{ij} \text{ values for}$

corresponding Y channel blocks} for blocks in the U and V channels;

5 (c) forming a global quantization matrix  $Q$  for the Y channel block and one for channels U and V combined such that a magnitude of each quantization matrix coefficient  $Q_{ij}$  is inversely proportional to an importance in the image of a corresponding DCT basis vector; and

10 (d) quantizing the transform coefficients for each of the Y, U and V channels by dividing them by a factor  $S_{ij} Q'$ , where  $S_{ij}$  is a linear scaling factor for each of channels Y, U and V and  $Q'$  is the quantization table for the associated channel being quantized; and

15 (e) entropy encoding quantized coefficients  $T_{ijmn}$  and  $Q' * S_{min}$ , where  $S_{min}$  is a user selected minimum scaling factor for each of channels Y, U, and V, to create a JPEG image file for each of channels Y, U and V.

20 9. The method of claim 8 wherein the shrinking factor is  $1/2$ .

10. Apparatus for JPEG compression of an image frame  
25 divided up into a plurality of non-overlapping, tiled  $8 \times 8$  pixel blocks  $B_{ij}$  where  $i, j$  are integers covering all of the blocks in the image frame, comprising:

(a) a discrete cosine transformer (DCT) operative to form the discrete cosine transform of each block  $B_{ij}$  of the image frame to produce a matrix of blocks of transform coefficients  $D_{ij}$ ;

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(b) a visual importance calculator operative to calculate the visual importance,  $I_{ij}$ , for each block of the image, based upon assigning zeros for flat features and values approaching unity for sharply varying features;

(c) a global quantization matrix calculator operative to calculate the global quantization matrix,  $Q$ , by one of

(i) selecting a standard JPEG quantization table and

(ii) selecting a quantization table such that the magnitude of each quantization matrix coefficient  $Q_{ij}$  is inversely proportional to the importance in the image of the corresponding DCT basis vector;

and

(d) a linear scaling factor calculator operative to determine a linear scaling factor,  $S_{ij}$ , defining bounds over which the image is to be variably quantized based on user established values of  $S_{\max}$  and  $S_{\min}$ ;

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(e) a quantizer operative to divide the transform coefficients,  $D_{ijmn}$ , by a value equivalent to dividing them by a factor  $S_{min} * Q$ , where  $S_{min}$  is a user selected minimum scaling factor, and

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(f) an entropy encoder operative to encode the quantized coefficients  $T_{ijmn}$  and  $Q * S_{min}$  to create a JPEG image file.

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10 11. Apparatus according to claim 10, wherein said quantizer rounds  $(D_{ijmn} / (S_{min} * Q))$  to the nearest integer to form quantized DCT transformed coefficients  $T_{ijmn}$  and

(a) sets  $T_{ijmn} = 0$  if  $\text{round}(D_{ijmn} / (Q_{mn} * S_{ij})) = 0$ ; and

(b) sets  $T_{ijmn} = \text{sign}(D_{ijmn}) * (2^{(\text{ceil}(\lg(\text{abs}(D_{ijmn})+1))-1)} - 1)$  if  $\text{abs}(D_{ijmn}) - (2^{(\text{ceil}(\lg(\text{abs}(D_{ijmn})+1))-1)} - 1)$  is less than or equal to  $\text{abs}(D_{ijmn} - Q_{mn} S_{ij} * \text{round}(D_{ijmn} / (S_{ij} * Q_{mn})))$ ;

20 12. Apparatus according to claim 10, wherein said linear scaling factor calculator determines a linear scaling factor  $S_{ij}$  equal to  $I_{ij} * (S_{max} - S_{min}) + S_{min}$  where  $S_{min}$  and  $S_{max}$  are user specified to define bounds over which the image will be variably quantized.

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